2

AD-A192 937

AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

PILOT REPORT: AFTI F-111

MAJOR SCOTT E. PARKS 88-2050

"insights into tomorrow"

88 5 10 300

DISCLAIMER

The views and conclusions expressed in this document are those of the author. They are not intended and should not be thought to represent official ideas, attitudes, or policies of any agency of the United States Government. The author has not had special access to official information or ideas and has employed only open-source material available to any writer on this subject.

This document is the property of the United States Government. It is available for distribution to the general public. A loan copy of the document may be obtained from the Air University Interlibrary Loan Service (AUL/LDEX, Maxwell AFB, Alabama, 36112-5564) or the Defense Technical Information Center. Request must include the author's name and complete title of the study.

This document may be reproduced for use in other research reports or educational pursuits contingent upon the following stipulations:

- Reproduction rights do not extend to any copyrighted material that may be contained in the research report.

- All reproduced copies must contain the following credit line: "Reprinted by permission of the Air Command and Staff College."

- All reproduced copies must contain the name(s) of the report's author(s).

- If format modification is necessary to better serve the user's needs, adjustments may be made to this report--this authorization does not extend to copyrighted information or material. The following statement must accompany the modified document: "Adapted from Air Command and Staff College Research Report ______ (number) ______ entitled ______ (title) ______ by ______ (author)."

- This notice must be included with any reproduced or adapted portions of this document.

REPORT NUMBER 88-2050

TITLE PILOT REPORT: AFTI F-111

AUTHOR(S) MAJOR SCOTT E. PARKS, USAF

FACULTY ADVISOR WING COMMANDER JOHN P. DACRE, ACSC/3824 STUS

SPONSOR MR STEPHEN SMITH, 6510 TEST WING/TEG

Submitted to the faculty in partial fulfillment of
requirements for graduation.

AIR COMMAND AND STAFF COLLEGE
AIR UNIVERSITY
MAXWELL AFB, AL 36112-5542

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

A 1 1 , 937

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: STATEMENT "A" Approved for public release; Distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S): 88-2050	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION: ACSC/EDC; 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code): Maxwell AFB AL 36112-5542	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION; 8b. OFFICE SYMBOL (if applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
PILOT REPORT: AFTI F-111

12. PERSONAL AUTHOR(S)
Parks, Scott E., Major, USAF

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
	FROM ______ TO ______	1988 April	19

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The Advanced Fighter Technology Integration (AFTI) F-111 research program is designed to evaluate a new wing design called the Mission Adaptive Wing (MAW). The MAW has the ability to continuously change it's shape in flight. This article provides a non-technical overview of the program with emphasis on the flight test and future uses of the wing on bomber, transport, and fighter aircraft.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL: ACSC/EDC Maxwell AFB AL 36112-5542	22b. TELEPHONE (Include Area Code): (205) 293-2867; 22c. OFFICE SYMBOL

DD Form 1473, JUN 86 Previous editions are obsolete. SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

PREFACE

This paper is a review of the Advanced Fighter Technology Integration (AFTI) F-111 research program, designed to test the feasibility of an advanced wing design called the Mission Adaptive Wing. A discussion of the Mission Adaptive Wing concept and test program is included as well as an analysis of future uses of the unique wing. The document is written in non-technical terms and is intended to inform readers not familiar with the AFTI F-111 on the program's accomplishments and potential for improving aircraft performance.

The paper was prepared in fulfillment of the research phase of the curriculum of the Air Command and Staff College, Maxwell AFB, Alabama. It is also intended as an article for publication and, subject to clearance, will be submitted to Air Force Magazine for consideration. The format of the manuscript conforms to the requirements established by the Air Force Magazine editors.

Special thanks is due to Wing Commander Phil Dacre for his tremendous ability with the English language and his patience in editing the manuscript.

ABOUT THE AUTHOR

Major Parks came to ACSC from the 6510th Test Wing Edwards AFB where he served in a number of positions including Chief of Systems and Test Management for the USAF Test Pilot School, Chief of Operations for the F-111 Avionics Modernization Program Test Force, and Project Pilot for the Advanced Fighter Technology Integration (AFTI) F-111 Test Team. Prior to that, he was assigned to the 4950th Test Wing at Wright Patterson AFB as a Test Director and C-135 Research Pilot. He is a graduate of the USAF Test Pilot School, and holds a Masters Degree in Aeronautical Engineering from the Air Force Institute of Technology, and a Bachelors Degree in Mechanical Engineering from Georgia Tech. Previous publications include Transient Flow Analysis of an Aircraft Refueling System published in the December 1983 issue of the American Institute of Aeronautics and Astronautics Journal of Aircraft.

TABLE OF CONTENTS

Preface....iv
List of Illustrations....vii
Executive Summary....viii

PILOT REPORT: AFTI F-111
Testing a New Aircraft....3
How the Wing Works....5
What Can the Wing Do....7
So, What's the Catch....10

BIBLIOGRAPHY....12

LIST OF ILLUSTRATIONS

FIGURES

FIGURE 1--Mission Adaptive Wing in Cruise Flight................2

FIGURE 2--Mission Adaptive Wing in Fully Cambered Position......6

FIGURE 3--AFTI F-111 Cockpit..................................8

EXECUTIVE SUMMARY

REPORT NUMBER 88-2050

AUTHOR(S) MAJOR SCOTT E. PARKS, USAF

TITLE PILOT REPORT: AFTI F-111

The body of this report is intended as a nontechnical overview of the Advanced Fighter Technology Integration (AFTI) F-111 test program written in a format suitable for publication in Air Force magazine. The purpose of the article is to inform a wide audience on the test results to date and to present potential uses for the emerging technology.

The AFTI F-111 is a research program sponsored by the Air Force Flight Dynamics laboratory designed to test a new wing concept called the Mission Adaptive Wing (MAW). This unique wing design is capable of continuously changing its shape in flight to optimize the aircraft's performance for any flight condition. The wing is designed by Boeing who also had responsibility for integrating the wing into the pre-production NF-111 test bed. This aircraft was used for a previous test program called Transonic Aircraft Technology (TACT) which demonstrated the performance benefits of a wing shape called the supercritical airfoil. This is the basis for the uncambered shape of the MAW. Flight test is a joint responsibility of NASA Dryden and the Air Force Flight Test Center with engineering and piloting responsibilities shared by both organizations.

The test program is divided into two phases. The first phase, the manual mode test, was completed in November 1986 and met its objective of proving the MAW's functional capability and aerodynamic potential. The second phase, the automatic modes test, is currently in flight test at Edwards AFB and will demonstrate the ability of these modes to maintain aerodynamic efficiency and operational flexibility without adding to pilot workload or interfere with other pilot tasks.

The wing consists of a fixed center section with movable leading and trailing edges. These surfaces are hydraulically driven and controlled via duel digital computers. Cockpit control is with a control panel and the pilot's control stick.

Potential uses for the MAW include applications for fighter as well as bomber and transport designs. Benefits for fighters include improved maneuverability and/or increased sustained and instantaneous "g". Bombers and transports can achieve improved fuel consumption which equates to better range and endurance.

The AFTI F-111 test program is just the first step in proving the concept of the Mission Adaptive Wing. While there are unquestioned performance benefits they will have to be weighed against the wing's design complexity.

PILOT REPORT: AFTI F-111

BY MAJOR SCOTT E. PARKS, USAF

Birds are clearly beautiful and efficient flying machines. I often have observed hawks flying above the high desert at Edwards AFB, effortlessly positioning their wings to the optimum shape learned through instinct and experience. They soar smoothly in the summer afternoon thermals with wings comfortably forward only to suddenly dive for an unsuspecting target at high speed with wings swept back. Landings, on the other hand, require the hawk's wing to be forward and highly curved or cambered as they turn into the wind to achieve the slowest possible approach speed. Precise control is achieved by small changes in the position of the feathers located on the wing tips.

Aircraft designers, having less experience with flight than the Almighty, have been constrained to a fixed wing shape that is optimum for only one flight condition. This means that in other flight conditions the wing is a compromise which results in reduced range and/or payload. Prior to the jet age, optimizing wing shape was not a concern because of limitations in aircraft altitudes and airspeeds. Later expansion of the flight envelope, with the advent of jet-powered supersonic fighters and bombers, forced designers to recognize the critical need for a variable shape wing. High performance aircraft need a wing that is efficient at high subsonic and supersonic speeds and at the same time can keep approach speeds for landing reasonable. Flaps are one answer to this dilemma.

Flaps have been used for many years to allow aircraft to fly at lower approach speeds on landing. As aircraft materials and control systems have been improved flaps have been automated and their use extended to flight at high speeds and elevated load factor. Flaps used for this purpose are often called maneuvering flaps. A number of current aircraft employ maneuvering flaps including the F-16 and F-18. Maneuvering flaps give designers some ability to improve wing performance throughout the flight envelope.

The Advanced Fighter Technology Integration (AFTI) F-111 research program is designed to flight test a totally new wing concept called the Mission Adaptive Wing (MAW). This wing, just like the hawk's wing, optimizes its performance by continuously and smoothly changing shape in flight. The AFTI F-111, figure 1, was one of two programs sponsored by the Air Force Flight Dynamics Laboratory (AFFDL) and NASA; the other program being the AFTI F-16. I had the opportunity to be one of the two initial Air Force test pilots to fly the AFTI F-111 and was active in the program from March 1984 through my departure from Edwards AFB in July 1987. We began a two phase flight test program evaluating the MAW concept in 1985. Phase I, completed in November 1986, met its objectives by determining the feasibility of a MAW on high performance aircraft. The second phase, currently in flight test

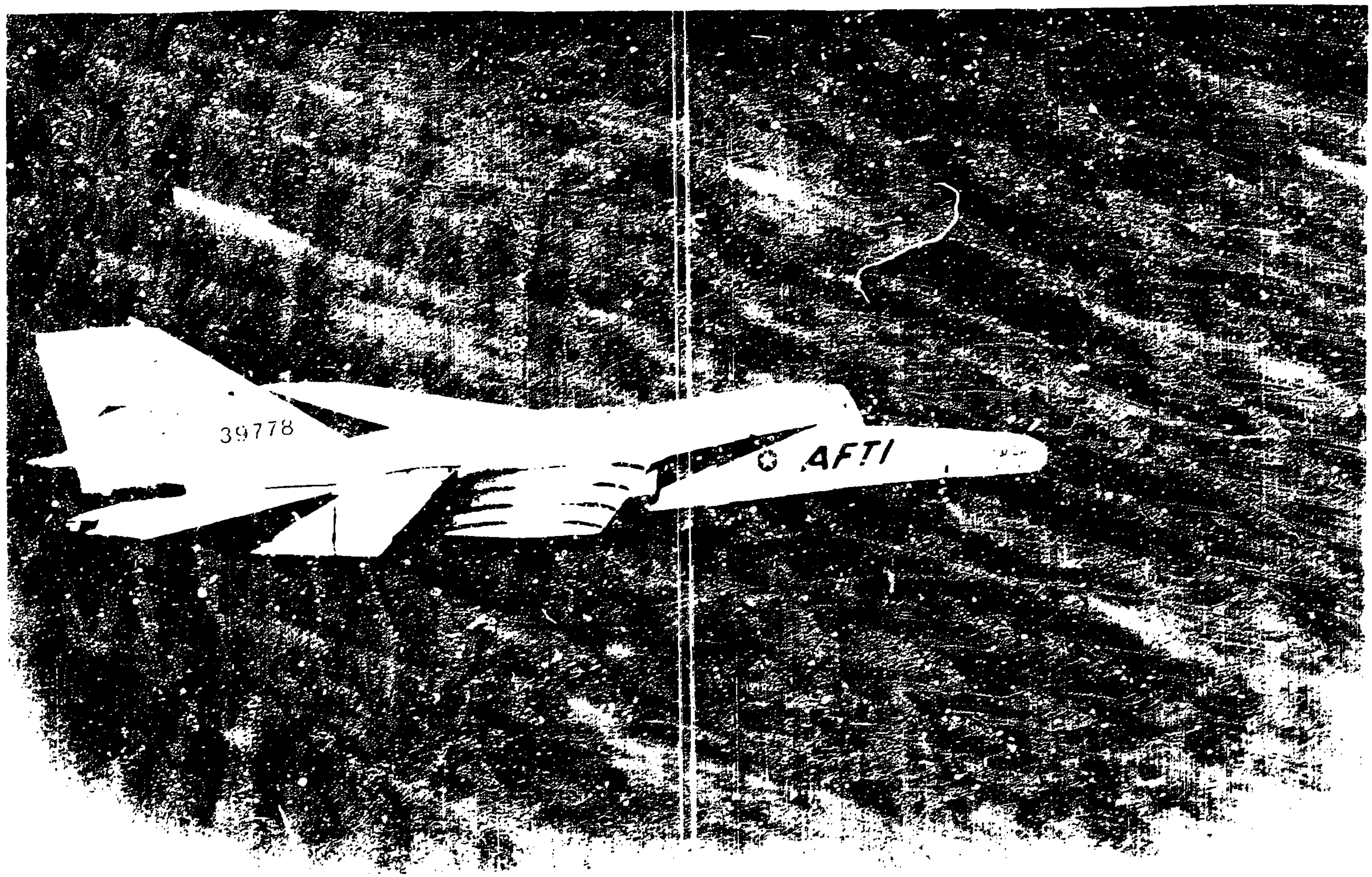

Figure 1 Mission Adaptive Wing in Cruise Flight

at Edwards AFB, is demonstrating potential uses for this unique wing design. However, before we go into the detailed aspects of the program, it will help the reader to understand the concept by first looking into the historical background. Later we can examine future applications of the MAW in the design of fighters, transports and bombers.

The F-111 aircraft we used for AFTI was previously flown in a program called Transonic Aircraft Technology (TACT) from 1973 to 1979. TACT tested a unique wing shape called the supercritical airfoil which improved cruise performance in high subsonic flight and verified the performance advantage of this type of wing in cruise flight. An advanced version of this type airfoil became one of the many shapes of the Mission Adaptive Wing.

Boeing received the contract for design and fabrication of the MAW wing in 1979 and had responsibility for integrating the wing into the pre-production NF-111 test bed and initial system checkout. They also performed an extensive amount of wind tunnel tests which were used to predict the wing's performance in flight. Technical support is currently provided by Boeing for the wing and General Dynamics for the non-wing airframe and subsystems. Flight test is a joint NASA/Air Force Flight Test Center (AFFTC) effort with both organizations sharing the engineering and piloting responsibilities. The flight test is also jointly managed by Mr Louis Steers (NASA) and Mr Steve Smith (AFFTC).

TESTING A NEW AIRCRAFT

Simulation played an important role in the engineering development of the MAW. Two flight simulators were used; one at Boeing from 1981 to 1984 and the other at NASA Dryden from 1984 to the present. Flying simulators is definitely not the most popular part of a program for the pilots but for every hour in flight we spent many times that in the simulator.

Prior to first flight, our knowledge of how the aircraft would fly was very limited thus requiring many hours "in the box" evaluating controllability. In addition, the simulator was extremely useful in developing emergency procedures. For example, we found under certain flight conditions the aircraft would be uncontrollable if there were an uncommanded asymmetry between the left and right wings. This knowledge changed our operating procedures to avoid this condition. Also, the flight profile for every test flight is flown fir t on the simulator which allows the pilots to make maximum use of available flight time.

First flight of the AFTI F-111 was treated as if we were flying a new aircraft. While externally the aircraft looks somewhat like an F-111, the unique wing and internal changes created many unknowns that required a cautious approach. The flight profile consisted of little more than takeoff, systems checks, controllability evaluation, and landing and was flown in the simulator many times prior to flight. The day before the first flight a dress rehearsal was conducted with the control

room operational and a high speed taxi down the runway. Control room operation is similar to Houston control for space launches and contains experts in every facet of the aircraft. One individual is designated NASA 1 and is the only person allowed to communicate with the aircraft.

The day of first flight is extremely exciting because it's the culmination of years of work by many people. Lt Col Frank Birk (USAF) and Rogers Smith (NASA) manned the aircraft while I flew chase in a T-38 and Einar Enevoldson (NASA) was NASA 1. The initial takeoff was made toward the dry lake bed at Edwards in case of an abort. To the satisfaction of all involved the flight went flawlessly and began phase one of testing. It's noteworthy that the first flight also established a new flying specialty. The project test pilots when flying in the right seat did not appreciate being referred to as co-pilot or navigator. Wishing to alleviate the problem, Steve Smith created a new specialty, the Mission Adaptive Wing Systems Operator or MAWSO. MAWSO thence forth became the standard reference for the pilot flying the right seat.

As mentioned earlier, the flight test is divided into two phases with the objective of the first phase to determine the operation and basic aerodynamics of Mission Adaptive Wing. This includes the verification of structural integrity and controllability. We accomplish this by cautiously expanding the flight envelope of the aircraft in altitude, airspeed, and load factor ("g"). Within that envelope actual performance data could then be collected. Results indicate the potential exists to meet or exceed the performance goals established from wind tunnel data. Comparing TACT and MAW, the goals include a 30% increase in range, a 20% increase in sustained turn radius, and a 30% increase in usable buffet free lift (1,97).

Systems evaluations are also conducted to verify proper operation and of the MAW and its interface with the aircraft. Operation with one hydraulic system or one engine out was of particular concern and a significant amount of ground testing was required to termine if the wing could operate under these adverse conditions. An unplanned test of this was almost conducted on the aircraft's third flight and my first flight when the chase plane noted a massive hydraulic leak from the bottom of the aircraft. Recovery was made without any problem and the leak was found to be unrelated to the MAW.

Results of the first phase were very encouraging. The wing's performance has lived up to expectations. The drag reduction benefits of the wing were very close to those predicted during wind tunnel testing. Aircraft handling was excellent (similar to the production F-111) with the exception that approach speeds for landing were 25 to 30 knots above the standard F-111. Normal approach speeds could be achieved with the MAW but were not required to meet the objectives of the research program.

In phase II, four different modes are being evaluated to demonstrate potential uses for the Mission Adaptive Wing. Two f these modes have already been flown, cruise camber control (CCC)

and maneuver camber control (MCC). CCC operates by deflecting the trailing edge of the wing and sensing speed change. The mode will continue deflecting the wing until maximum speed for a given power setting is achieved. MCC operates by continuously positioning the wing to its optimum shape as a function of "g" and Mach number. Test results for MCC have been excellent. Pilots indicate that they are unaware the mode is operating with the exception that handling is improved in pitch. Testing of CCC has been less successful and further refinement of the mode will be required.

Two modes are yet to be tested: Maneuver Load Control (MLC), and Maneuver Enhancement/Gust Alleviation (MEGA). MLC will operate by computing bending loads at the wing root and changing the wing shape to prevent exceeding predetermined limits. MEGA actually has two functions. First, during cruise flight, it will act to reduce the aircraft's susceptibility to gusts and provide a smoother ride. Secondly, during maneuvering flight, this mode will deflect the wing and horizontal stabilizer to make the aircraft more responsive in pitch.

HOW THE WING WORKS

The F-111 used in the research program is a pre-production "A" model that was used in the original F-111 flight test program and has never been brought up to the production standard. This fact produces some interesting problems for the maintenance team. Replacement parts have sometimes been difficult to come by, and unique "work-around" procedures had to be devised.

While the aircraft is already nonstandard, modifications made for the MAW test program make it truly unique. The existing wings are replaced with Mission Adaptive Wings and the fuselage is modified to allow the new wings to sweep aft without interference. Extensive instrumentation is added to the weapons bay to monitor every facet of the wing's operation. Computers for controlling the wing are housed in the nose.

Clearly the most significant modification to the aircraft is the wing itself. It is designed with a completely smooth upper surface and actuation mechanism housed totally within the wing. As shown in figure 2, the center portion of the wing (wing box) is fixed in shape with only the leading and trailing edges capable of deflection. The wing box was also used in the TACT program. The leading edge of the wing is a single span surface while the trailing edge consists of three panels capable of independent motion.

Both leading edge and trailing edges move approximately twenty degrees in their fully deflected positions. The upper surface of the leading and trailing edge is a composite material that actually bends to change the wing shape.

Power for actuation of the wing comes from the dual hydraulic systems found on the standard F-111. Each system is upgraded to increase its capacity and is capable of independently operating the wing. The eight hydraulic drive units, two for the

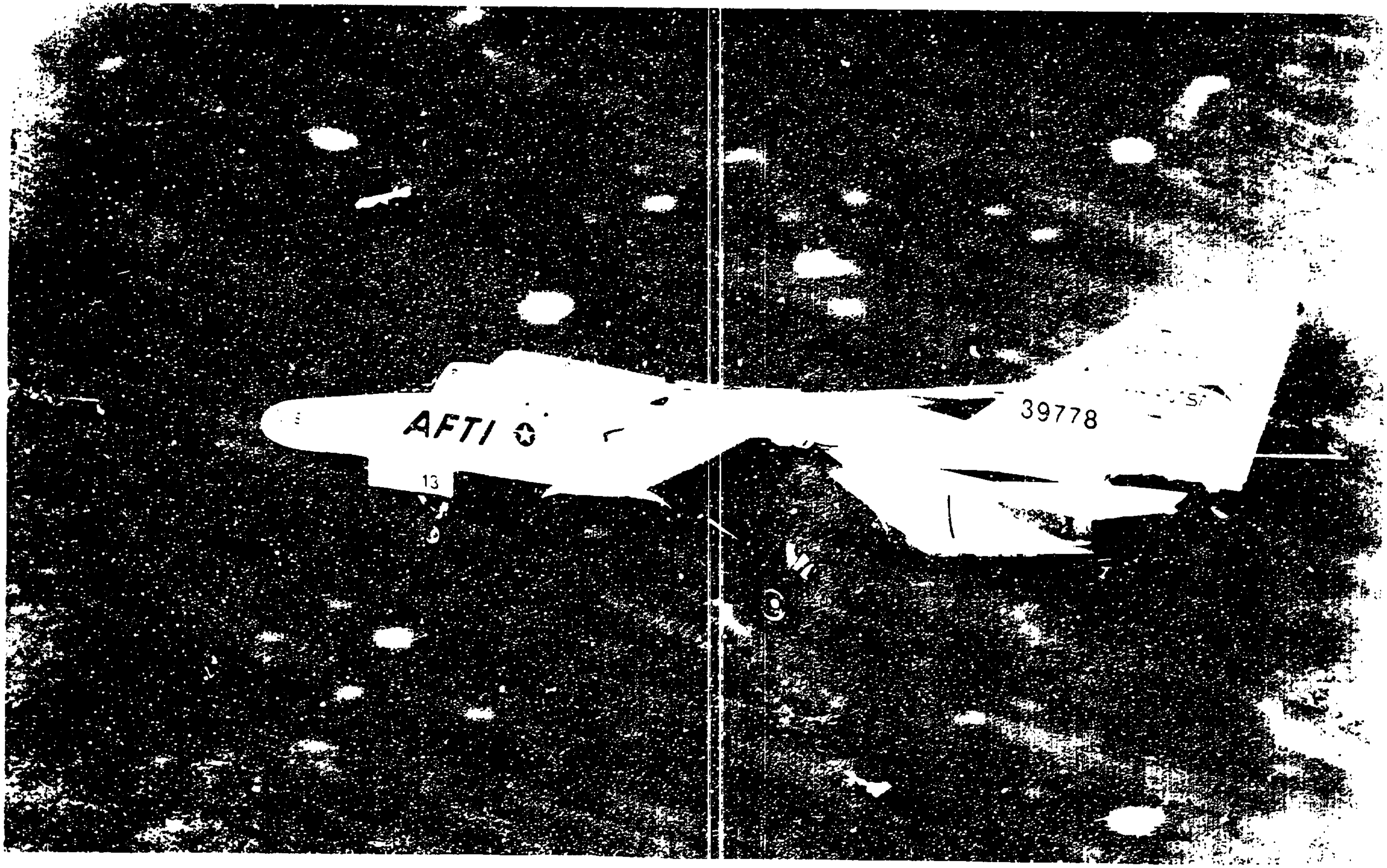

Figure 2 Mission Adaptive Wing in Fully Cambered Position

leading edge and six for the trailing edge, are capable of very fast response and require no mechanism external to the wing. Designing an entirely internal mechanism was a difficult but not insurmountable task for the Boeing and Garrett engineers.

Control of the wing is via dual digital computers with two analog computers used for back-up. Each digital computer commands one of the two drive units for each surface. The analog computers take over if the commands from the digital computers do not agree or other errors are detected. Without these digital high capacity computation devices the Mission Adaptive Wing would be nearly impossible.

Selection of manual and automatic modes is accomplished via a control panel located between the pilot and the MAWSO (Figure 3). With the wing operating in manual mode the single leading edge and three trailing edge sections on each wing can be independently positioned symmetrically to any desired position. In addition, through pilot's control stick inputs the midspan and outboard trailing edge panels move asymmetrically to assist in roll control. The fleet F-111 uses spoilers to accomplish the same function. All automatic modes can be engaged independently and some modes jointly via the control panel. For example Maneuver Camber Control and Maneuver Load Control could be selected to complement each other.

The control panel also provides cockpit warning of any MAW-related malfunctions and the ability to lock in place symmetrically each set of moveable panels. The gun trigger on the control stick is modified, in the event of a malfunction, to position the wing immediately to the wing shape tested during TACT. This gave us a very quick way of configuring the wing to a known configuration should something unexpected occur.

WHAT CAN THE WING DO

Current wing designs are a compromise involving many factors. Some of these include maneuverability, cruise performance and strength. Wings are optimized for one flight condition and then modified to obtain satisfactory characteristics throughout the flight envelope. This compromise creates a particular problem with fighter aircraft that have a large altitude and airspeed range and are required to possess maneuver capability up to high "g" levels. As "g" is increased a wing designed for level flight cruise becomes less efficient which limits the sustained "g" capability of the aircraft. The farther from design condition the aircraft is maneuvered the greater the loss in efficiency.

Flaps have been used for many years to allow a wing optimized for cruise flight to also provide reasonable approach speeds for landing. The increased drag associated with these surfaces and their structural design limits minimized their usefulness for cruise and maneuvering flight. As strong, lightweight materials became available, maneuvering flaps were designed that could be operated throughout a majority of an

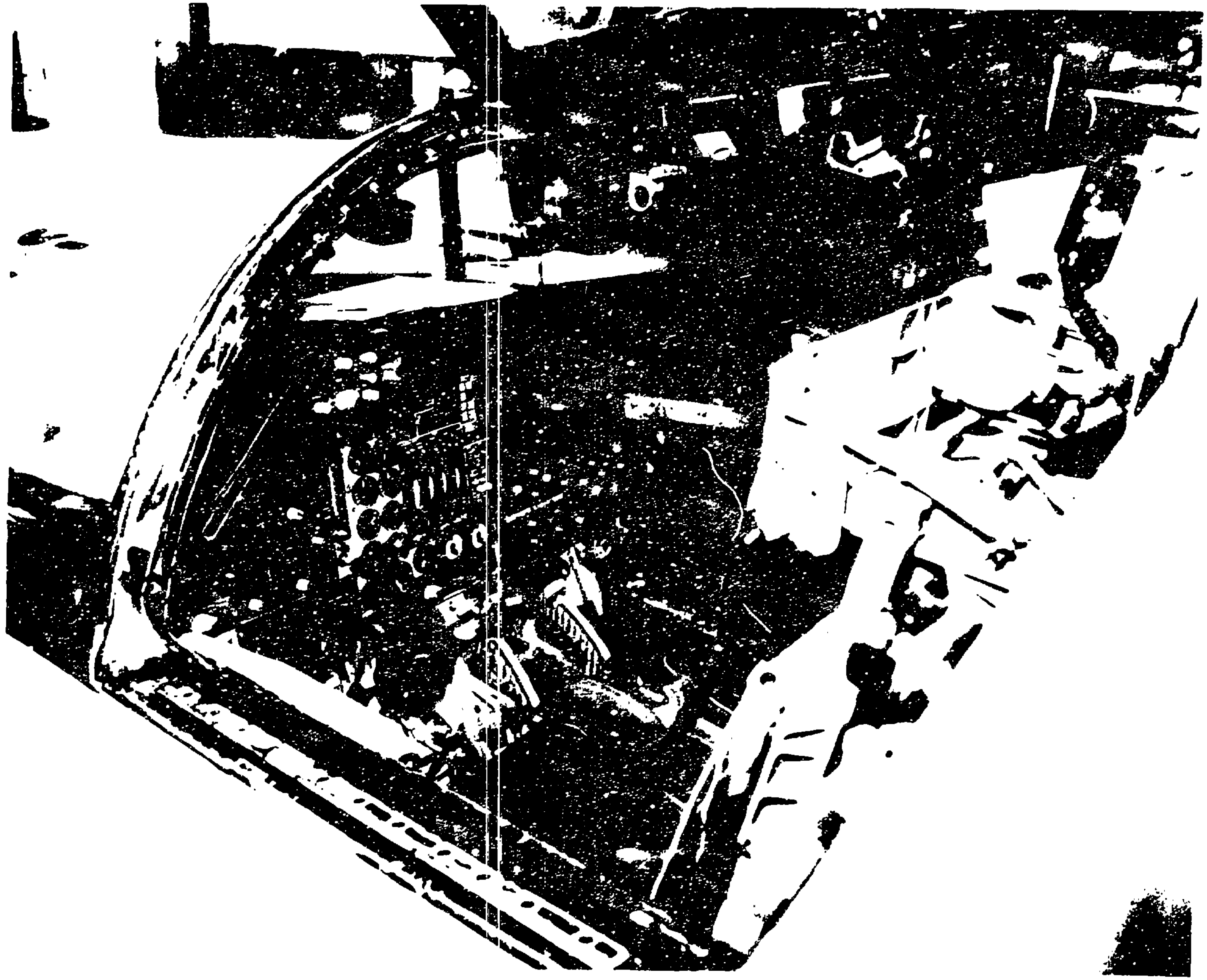

Figure 3 AFTI F-111 Cockpit

aircraft's flight envelope. Improvements in flight control systems allowed operation of maneuvering flaps to be automated. Current generation fighter aircraft use maneuvering flaps to improve performance during maneuvering flight such as air combat. For example, the F-18 automatically deflects both it's leading and trailing edge flaps as the wing reaches high angles of attack. The great disadvantage of these surfaces is high drag, as compared to a smooth surface, when they are in operation.

The Mission Adaptive Wing solves this problem. An F-16 operating with Maneuver Camber Control described previously would have its wing continuously changing shape as a function of flight condition which would provide the pilot higher sustained "g" capability and higher overall energy level. Both of these are important to aerial combat.

Another example of improved maneuverability that could be provided by the Mission Adaptive Wing is a concept called "direct lift". When a pilot commands a change in pitch the wing deflects in combination with other control surfaces to produce a change in flight path. This mode allows the aircraft to be more responsive to pilot inputs and can increase a fighter's ability to generate instantaneous "g".

A number of other features inherent in the design of the Mission Adaptive Wing have the potential to improve fighter, bomber and transport performance. One of these is the ability to change the distribution of air loads along a wing while in flight. For long range missions it is desirable to increase the ratio of a wing's length to its width (chord) thus increasing it's aspect ratio. The ability to do this is limited by structural loads at the wing root which increase as a function of wing length. The stiff, low aspect ratio wings of most fighter aircraft result from their need to achieve high "g" and the resulting high wing loads. Even in cruise flight the aspect ratio of a wing is limited by the need to provide a safety factor for protection from gusts. A limited solution to this problem is employed by aircraft such as the U-2 in which the pilot can manually reposition the outboard aileron to reduce the loads at the wing root. A mission adaptive wing can carry this concept much further.

The MAW, with it's digital control system and fast response time, can continuously compute the loads at the wing root and change the camber of the outboard section of the wing as required to control those loads. For fighters this means wings that have lower structural weight or can achieve higher maximum "g". In transport and bomber designs, the higher aspect ratio wings allowed by the concept of load control can produce improved fuel consumption and longer range and endurance.

All aircraft, regardless of mission, cruise during some portion of their flight profile. The traditional fixed wing shape is suitable for aircraft, such as transports, that cruise at a fixed speed and altitude. Other aircraft, such as strategic bombers and fighters, which must cruise at high altitude as well as ingress to a target area at low altitude and high speed would

benefit from the Mission Adaptive Wing concept.

The MAW with cruise camber control deflects the trailing edge of the wing until maximum forward velocity is obtained regardless of flight condition. This is especially effective for an aircraft such as the Advanced Tactical Fighter that must cruise in both the subsonic and supersonic flight regimes. This concept may also allow aircraft to achieve higher maximum altitudes which may be important for reconnaissance applications (2,--). Another benefit is the MAW's capability to provide maximum performance even when carrying external stores.

The gust alleviation mode is especially important for aircraft required to cruise at low altitude and high speed. Good low level ride quality is generally associated with aircraft that have high wing loading (force per unit area) on the wing, for example the production F-111. The disadvantage of high wing loading is a large rate of energy loss when the wing is subject to "g". The Mission Adaptive Wing Can achieve the same ride quality with lower wing loading.

SO, WHAT'S THE CATCH

The first thought most everyone has is that the MAW must be heavier, more complex and more costly to maintain than existing wing-flap designs. This is not true. Mr Ron DeCamp, AFFDL program manager for the AFTI F-111, provides excellent answers to these common misconceptions. Using the F-111 as an example, Mr DeCamp states that replacing the existing complex arrangement of slats and flaps with a production version of the MAW would actually save approximately 600 pounds. Also, maintenance costs may actually be reduced. Current aircraft with slots, slats and flaps have crevices that collect dirt, ice, snow, etc. which, in turn, can jam the sliding tracks and hinges. The MAW mechanisms, on the other hand, are completely sealed which Boeing estimates may reduce maintenance requirements by as much as 35%. As to complexity, the MAW is no more complex than the maneuvering flap designs found on current generation fighters. Another misconception is that the MAW mechanisms extend into the wing fuel cavity thus reducing aircraft fuel capacity. Not true! All mechanisms of the MAW leading and trailing edges are confined to areas formerly occupied by high lift devices.

This section would not be complete without addressing the higher approach speeds used on the AFTI F-111 research vehicle. These speeds were dictated by the production F-111 design which limits the landing angle of attack to prevent the tail from contacting the runway. Designers could use one of two approaches on future aircraft to provide satisfactory speeds for landing. The most desirable approach is to design the aircraft to land at a higher angle of attack taking advantage of the higher stall angle of attack available with the Mission Adaptive Wing. The second approach is to add existing high lift devices to the MAW. This alternative is less desirable due to the added weight and complexity.

In short, "the catch" is that designers must be ready to develop a new airfoil shape for each of the many flight conditions future aircraft must encounter. This will make for a more complex design process, one in which all disciplines (structures, flight controls, aerodynamics, etc.) must work more closely together.

As I have discussed in the preceding paragraphs, the AFTI F-111 research program to date has been quite successful. The first phase of testing, completed in November 1986, proved the Mission Adaptive Wing functional capability and aerodynamic potential. The current phase of testing, slated for completion in 1988, is evaluating the automatic modes and the ability to maintain aerodynamic efficiency and operational flexibility without adding to pilot workload or interfere with other pilot tasks.

Future applications of the MAW include improved aircraft maneuverability, control of load distribution on the wing, better ride qualities and improved cruise performance. This equates to enhanced range and payload for bombers and increased "g" capability and reduced energy loss during maneuvering for fighters.

The AFTI F-111 test program is just the first step in proving the concept of the Mission Adaptive Wing. While there are unquestioned performance benefits they will have to be weighed against the wing's added design complexity. As with any new idea it must be integrated in light of real world constraints. While much work is yet to be done the AFTI F-111 is a giant first step.

BIBLIOGRAPHY

A. REFERENCES CITED

1. Birk, F. T., Smith, R. E. "AFTI F-111 Mission Adaptive Wing Test Program." The Society of Experimental Test Pilots Thirtieth Symposium Proceedings, pp. 86-100.

2. Decamp, R. W. Advanced Fighter Technology Integration (AFTI) F-111 Program Manager, Aeronautical Systems Division, Wright Patterson AFB, Ohio. Telecon, November 1987.

B. RELATED SOURCES

1. DeCamp R. W., Hardy, R., Gould, D. K. "Mission Adaptive Wing" SAE Technical Paper Series, Society of Automotive Engineers, Warrendale Pennsylvania.

2. National Aeronautics and Space Adminstration. AFTI/F-111 Flight Manual. Report No. MAW 85-70. Edwards AFB, CA: Ames Research Center, Dryden Flight Research Facility, August 1985.

3. ----. AFTI/F-111 Flight Test Plan. Report No. MAW 85-40. Edwards AFB, CA: Ames Research Center, Dryden Flight Research Facility, July 1985.

GLOSSARY

AFFTC	Air Force Flight Test Center
AFTI	Advanced Fighter Technology Integration
CCC	Cruise Camber Control
g	Load Factor
MAW	Mission Adaptive Wing
MCC	Maneuver Camber Control
MEGA	Maneuver Enhancement/Gust Alleviation
MLC	Maneuver Load Control
NASA	National Aeronautics and Space Adminstration
TACT	Transonic Aircraft Technology